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FY16 T45 Contingency Base Site Evaluations for the Tactical Environment

Strategic Siting of Contingency Bases: Assessing Options for Potable Water

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Construction Engineering
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Abstract

If strategically sited, a contingency base (CB) can serve as a force multiplier in relations between governments and civilians. Although both of the U.S. Army's key doctrinal sources for CB planning and design clearly recognize that CBs are affected by host-nation populations and also affect those populations directly, neither source provides much concrete help to the planners who are expected to analyze those reciprocal impacts. Yet, while deployed in a foreign nation, U.S. military commanders and planners must be cognizant of how their actions can impact U.S. military operations for good or for ill. This work supports military planners tasked with selecting CB locations by presenting an assessment framework to conduct a scientifically supportable socioecological systems analysis of a CB's use of a resource—in this case, potable water. The proposed assessment framework will enable the U.S. Army to consider the ramifications of siting CBs as part of military operations. Addressing data sources and analytical methodologies will be part of follow-on research efforts.

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Preface

This study was conducted for the Department of the Army under applied research program element T45, Project 45509, "Contingency Base Site Evaluations for the Tactical Environment." The technical monitor was Mr. Kurt Kinnevan, CEERD-CZT.

The work was performed by the Environmental Processes Branch (CNE) and the Land and Heritage Branch (CNC) of the Installations Division (CN), U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL). At the time of publication, Mr. Garth Anderson was Chief, CEERD-CNE, and Dr. Michael Hargrave was Chief, CEERD-CNC; Ms. Michelle Hanson was Chief, CEERD-CN; and Mr. Kurt Kinnevan, CEERD-CZT, was the Technical Director for Adaptive and Resilient Installations. The Deputy Director of ERDC-CERL was Dr. Kirankumar Topudurti, and the Director was Dr. Ilker Adiguzel.

The Commander of ERDC was COL Bryan S. Green, and the Director was Dr. Jeffery P. Holland.

Unit Conversion Factors

Multiply	By	To Obtain
gallons (U.S. liquid)	3.785412 E-03	cubic meters

Abbreviations

Term	Meaning
ASCOPE	areas, structures, capabilities, organizations, people, events
ATP	Army Techniques Publication
CB	contingency base
OCONUS	outside the Continental United States
EP	Engineer Pamphlet
ERDC-CERL	Engineer Research and Development Center–Construction Engineering Research Laboratory
TB MED	Technical Bulletin Medical

1 Introduction

1.1 Background

If strategically sited, a contingency base (CB) can serve as a force multiplier in relations with governments and civilians (Army Techniques Publication [ATP] 3-37.10). Strategic siting involves taking into account the function of the CB with regard to the mission; it also includes anticipating the impacts of the daily operation of the CB on the surrounding population and, reciprocally, of the population on the CB. Although both of the U.S. Army's key doctrinal sources for CB planning and design (ATP 3-37.10 and Engineer Pamphlet [EP] 1105-3-1) clearly recognize that CBs are affected by host-nation populations and also affect those populations directly, neither source provides much concrete help to the planners who are expected to analyze those reciprocal impacts. Both doctrinal sources rely, in the main, on the civil considerations category of the mission variables and on the mnemonic device familiarly employed to classify those considerations, ASCOPE (areas, structures, capabilities, organizations, people, events).

The Army defines potable water as "[w]ater that has been tested and approved by preventive medicine personnel to meet the short-term potability or long-term potability standards, and is therefore considered safe to drink for the period that the standards apply to" (Technical Bulletin Medical [TB MED] 577). The Army already has algorithms for calculating its drinking water needs given usage per soldier, the population of the CB, and the duration of occupancy.[1] What is lacking in a commander's toolbox, however, is a means for considering how a CB's use of a resource might impact the local population, either positively or negatively. As Hering et al. (2015) rightly observe, "[I]t is at the local level that interactions, tradeoffs, and choices matter most."

[1] ATP 4-44, for example, includes tables A-1 and A-2 that present standard planning factors related to personnel in force (gal/person/day).

1.2 Objective

This work supports military planners in establishing the location of CBs by presenting an assessment framework within which they can conduct a scientifically supportable socioecological systems analysis of a CB's use of a resource—in this case, potable water.

1.3 Approach

In this study, the sociocultural impacts of the CB on the indigenous population are of primary concern. Beyond a consideration of the mere physical presence of water, an analyst also needs to take into account how the local populace values water and uses it. Peoples' use of a resource is influenced by cultural preferences and social dynamics, as well as by access to technology (e.g., infrastructure; see e.g., Swyngedouw 2004; Finewood and Holifield 2015). Cultural preferences regarding the acquisition and use of water influence the type, amount, and management of water that is used for household, commercial, industrial, and agricultural purposes. Social dynamics include the nature of governance; relations of power among social actors; and economic practice in the provision, management, and use of water. Thus the use of water can be viewed as taking place within a socio-ecological system, which is interlinked in its social, political, economic, cultural, and physical/environmental dimensions (Wiek and Larson 2012).

A framework of questions is organized around a consideration of impacts from five options that were identified to acquire potable water. For each option, questions are posed that are associated with: (1) the impacts of the population on the CB and (2) the impacts of the CB on the population. The questions are designed to gather data that will enable decision makers to consider how the Army might meet its demand for potable water, at what monetary cost, and with what impacts to the mission and to the local population.

2 Why Water?

2.1 Previous work

Previous ERDC-CERL work led to the development of a wide-ranging series of questions that highlight considerations important to understanding the social, cultural, political, and economic impacts on the population during a CB's life cycle (Krooks, Whalley, and Anderson 2012). It addressed in broad terms the full range of reciprocal socioecological impacts (such as the presence of world historical sites, the ins and outs of leasing land, and Army acquisition processes in host-nation contexts). The Army's present concern with operations in dense urban environments and megacities is expected to grow, since both are likely to increase in area and population (Harris, et al. 2014). This concern necessarily brings with it the need to consider the availability of potable water, as outlined by the following quotation:

> Urban growth typically affects demand for water, generation of runoff, costs of water infrastructure, water quality, and the efficiency of service delivery. These challenges can be exacerbated by the density of population and the social, economic, and environmental characteristics of urban settlements. (Farmani and Butler 2014, 84)

Clearly, all of the above challenges can also be exacerbated by the siting of a CB in or near an urban settlement. For that reason, water is addressed in greater detail here. The questions posed within the framework are relevant specifically to the acquisition, management, and use of potable water in support of the operations and maintenance of a CB throughout its life cycle (see Chapter 3).

2.2 The broader context

The Army's current focus on the likely need to operate in dense urban environments (Harris et al. 2014) has led this study to pay particular attention to water issues, because water issues are likely to be encountered in urban settlements anywhere in the world. This combination makes a study of water issues both timely and wise.

In the broader literature, water-related issues are most often framed in terms of sustainability and governance, and the following question is considered crucial: Is the system that provides water to the public organized in such a way as to be able to meet the needs of that public over the longer term, especially given rapid urbanization? It is the organization of the system overall that is the focus of Michael Rouse's work (Rouse 2013a, 2013b). He addresses the immediate and regional environments, physical infrastructure, management systems, and long-term planning (both local and regional). The questions in Chapter 3 were developed to address the Army's concerns in the context of site selection for CBs, and these questions take into account many of the concerns that Rouse raises in his work.

Another important strain of scholarship that has proven influential in the arenas of water sustainability and governance is that initiated by Arnim Wiek and Kelli Larson (2012) and carried on by others using their approach (Kuzdas 2012; Kuzdas, Yglesias, and Warner 2013; Larson, Wiek, and Keeler 2013). That approach, like Rouse's, is an eminently practical one that focuses on what people actually do with water and why they do it (Wiek and Larson 2012, 3155). The authors make explicit a broad range of water-related concerns under a number of headings that include "Supplies (sources, rights, and storage), Deliveries (distribution and treatment), Demands (uses and conservation), and Outflows (discharge and recharge)," among others (Larson, Wiek, and Keeler 2013). Although the focus of this constellation of work is on long-range sustainability (a concern that is not foremost among the Army's site-selection criteria), the reader can expect to find questions in Chapter 3 that draw on that body of work.

A number of studies that have originated in the context of military engineering and social science are also important in the specific context of this special report. On the engineering front, the work of Hart et al. (2014) is important, as is that of Anderson et al. (2013), which includes a number of brief CB case studies drawn from recent U.S. deployments. Hart et al. (2014) consider the role of the population as a creator and user of infrastructure in an evaluation of how that infrastructure meets societal needs culturally, socially, politically, economically, and technologically. Their analytical techniques are designed to be used in determining the desired future state of infrastructure that has been destroyed or altered as a result of armed conflict. Anderson et al. (2013) highlight key concerns related to the demand for water on nonpermanent Army installations outside the continental United States (OCONUS). With respect to the sociocultural impacts

of CBs on the local population, the work of Krooks, Whalley, and Anderson (2012) is foundational.

In the present study, the sociocultural impacts of the CB on the indigenous population are a primary concern. Erik Swyngedouw's work (2004) is particularly important in understanding the exercise of social power in water-related sustainability and governance. His focus on differential access (the question of who benefits from water services and who is excluded from the benefits of that service) is particularly illuminating. Furthermore, his insight that water scarcity in a particular region or city may be socially constructed rather than a matter of absolute scarcity in the natural environment is penetrating: "…nature is [presented as] the principal 'cause' of water scarcity rather than the particular political economic configurations through which water becomes urbanized in highly selective and socially uneven ways, resulting in a serious 'scarcity' for the poor and powerless and abundant waters for the socio-economic and political elites" (Swyngedouw 2004, 47). The reader will note among the questions in Chapter 3 a concern for this *cui bono* (who benefits?) concept as a crucial emphasis in understanding the impacts of the CB on the local population.

3 An Assessment Framework for Contingency Base Siting and Impact Considerations

3.1 Building the framework

Alcamo et al. (2003) summarize the ways in which a well-designed assessment framework supports decision making: it "provides a logical structure for evaluating the system, ensures that the essential components of the system are addressed as well as the relationships among those components, gives appropriate weight to the different components of the system, and highlights important assumptions and gaps in understanding."

The assessment framework herein is inspired by social impact analyses (International Association for Impact Assessment 2013; Turnley 2002; Sairinen 2009; Vanclay 2003). The framework will be useful in planning CBs prior to deployment and in conducting CB operations and maintenance activities. The framework also will benefit mission accomplishment, should it ultimately prove usable at the tactical level. The framework has been constructed to be compatible with course-of-action analysis in the Army's military decisionmaking process.

The framework is organized around a consideration of impacts stemming from the five options for the acquisition of potable water:

1. Purchase commercially produced, bottled/packaged water. [See TB MED 577, para 2-2a(3)(a)(c).]
2. Extract/collect bulk water by drilling wells.
3. Extract/collect bulk water from surface water sources.
4. Extract/collect bulk water from rainwater. [TB MED 577, para 2-3b(1) envisions this possibility.[2]]
5. Purchase bulk water from a local provider.

For each option, questions are posed in the framework that are associated with: (1) the impacts of the population on the CB, and (2) the impacts of the CB on the population. The questions are designed to enable decision

[2] However, the section says that any rainwater used for human consumption would still be subject to potability standards.

makers to consider how the Army might meet its demand for potable water, at what monetary cost, and with what impacts to both the mission and the local population. In this context, it is important to note that the Army's quality standards for potable water are the same regardless of the source of the water.

As addressed here, understanding the impact of a CB includes considerations relevant to the particular ways in which a CB might acquire water and how that water might be distributed to its residents. Questions are also proposed within each water-provision option that address the management of any waste that might result from the acquisition and distribution processes.

The individual questions may address social, economic, political, or environmental factors, but the questions relate directly to water only. For example, it is a given that the presence of a CB raises a host of interrelated issues across the range of environmental concerns, and this is clearly no less true for social, political, or economic considerations. However, in developing this example of what a CB-siting framework could look like, focus was placed on those impacts most directly related to the provision of potable water for consumption on the CB. The reader must also bear in mind that certain water-provision options addressed in this report will raise unique issues; thus, the various components of the framework cannot be structured to be perfectly parallel to each other.

3.2 Impact of purchasing commercially produced, bottled/packaged water

3.2.1 Population's impact on the CB

Acquisition

- What is the cheapest source (among U.S., host-nation, and third-country suppliers) of bottled/packaged water that meets the Army standards for potable water?

Distribution

- What is the most cost-effective option for transporting bottled/packaged water?
- How great is the risk of disruption to the delivery of bottled/packaged water?

3.2.2 CB's impact on the population

Acquisition

- Can bottled/packaged water that meets Army standards be acquired from a local producer and/or distributor?
- How will meeting Army demand impact the availability of water for local users?
- What are the economic, political, and social impacts of the Army's injection of money into the local economy?
- How will using a local producer and/or distributor contribute to building economic capacity?

Distribution

- Can local companies be used to transport bottled water? How will using local transport companies contribute to the cost of transporting bottled water?
- What are the economic and political impacts of the Army's injection of money into the local economy?
- How will using local transport companies contribute to building indigenous economic capacity?
- What is the impact to local roads, ports, and/or airstrips when they are used to transport bottled/packaged water (e.g., competition with local traffic or infrastructure degradation)?

Return (sanitation)

- What is the best option for responsible disposal of the waste associated with meeting the CB's demand for bottled/packaged water?
  - Is there a local market for recyclables?
  - Is there an environmentally responsible method for local incineration of bottles or packages, if they cannot be recycled?
  - Is there a contract in place for disposal of solid waste in a local landfill?
  - Should the Army remove bottles or packages, if they cannot be recycled, to a site that it controls?

3.3 Impact of extracting/collecting bulk water by drilling wells

3.3.1 Population's impact on the CB

Water rights/permits

- Will it be necessary to lease or purchase water rights and/or obtain a permit and pay fees to drill a well?
- How much time and expense is associated with these activities?

Acquisition

- Are there local companies the Army can hire that provide well-drilling services?
- How vulnerable are drilled wells to shortages due to drought; contamination by adversaries or from floodwaters, urban runoff, animal or human waste, or agricultural or industrial activities?
- What sort of treatment of well water will be necessary to meet Army standards, and how much will it cost?
- What is the life-cycle cost from installation through transition/close out?

Distribution

- What is the cost to the Army of treating and distributing well water?

3.3.2 CB's impact on the population

Water rights/permits

- Is there a process for the Army to lease or purchase water rights and/or obtain a permit to drill a well?
- Are there conflicts associated with the leasing or purchasing of water rights and/or obtaining a permit to drill a well? What sort of conflict would be created by the Army drilling a well vs. using a private or government-owned well?

Acquisition

- What are the economic, political, and social impacts of the Army's injection of money into the local economy?
- How will meeting Army demand impact the availability of water for local users?

- Could military activities improve the local population's access to water?

Return (sanitation)

- What is the impact on the local environment of wastewater from the military's treatment of the raw water extracted via wells?

Transition

- Will the system have to be dismantled when the Army leaves the area or can it be used by the locals?

3.4 Impact of extracting/collecting bulk water from surface water sources

3.4.1 Population's impact on the CB

Water rights/permits

- Is there a water-use rights issue?
- Is there a right-of-way issue for laying a distribution network?

Acquisition

- What sort of treatment of surface water will be necessary to meet Army standards, and how much will the treatment cost?

Distribution

- What is the life-cycle cost of extraction through transition/close-out?

3.4.2 CB's impact on the population

Water rights/permits

- Will obtaining a right-of-way for a distribution network create conflict?

Acquisition

- How will meeting Army demand impact the availability of water for local users?
- What are the economic, political, and social impacts of the Army's injection of money into the local economy?

Return (sanitation)

- What is the impact on the local environment of wastewater from the military's treatment of the raw water extracted from surface water?

Transition

- Will the system have to be dismantled when the Army leaves the area, or can it be used by the locals?

3.5 Impact of extracting/collecting bulk water by collecting rainwater

3.5.1 Population's impact on the CB

Acquisition

- Is rainwater collection used locally?
- Are indigenous knowledge, labor, and/or materials available that can be employed for Army use?
- What sort of treatment of rainwater will be necessary to meet Army standards and how much will it cost?
- What is the life-cycle cost from collection through transition/close out?

3.5.2 CB's impact on the population

Acquisition

- What are the economic, political, and social impacts of the Army's injection of money into the local economy?

Return (sanitation)

- What is the impact on the local environment of wastewater from the military's treatment of the raw rainwater?

Transition

- Will the system have to be dismantled when the Army leaves the area, or can it be used by the locals?

3.6 Impact of purchasing bulk water from a local provider

3.6.1 Population's impact on the CB

Acquisition

- What are the Army's options for obtaining a water provider (e.g., government with or without international partners, government-sanctioned authority, private-public partnership, cooperative, or private business)? Is there a standing organization (e.g., an official water authority) with which the Army can interact? Who are the key actors involved with gaining access to water?
- What is the monetary cost of purchasing bulk water?
- What sort of water treatment will be necessary to meet Army standards and how much will it cost?
- What is the capacity of water providers to meet the Army's demand?
    - What is the level of service provided to the consumer (e.g., 24/7 service at *x* gallons per minute, *x* gallons per minute for certain hours of the day or week, or is service intermittent and unpredictable?
    - What is the reliability of the source used by the provider (e.g., an aquifer affected by drought and/or excessive draw down, or a river with a seasonal fluctuation of water level)?
    - Are there unresolved issues that affect the reliability of the service? For example, are there reoccurring maintenance issues, unmet needs for rehabilitation/replacement of aging infrastructure, or nonrevenue/unaccounted-for water that will impact delivery of water on demand?
    - In the event of disruption, how resilient is the system (e.g., Hart et al. 2014, 60–64)?[3]

Distribution

- Does tapping into the provider's service require additional water lines laid to point of access?

[3] Hart et al. discusses the "infrastructure assessment model," which considers whether infrastructure is "Required, Ready, Organized, Tough, Redundant, and Prepared." Also, "the enemy" may not be the only social actor capable of disrupting service. For instance, in Delhi, India, activists from a dissenting caste were able to deny the provision of water to millions to people in 2016 because of the city's dependence on one major canal.

- If existing water lines are usable, does the water they transport meet Army standards for potable water, or is treatment/disinfection required?

3.6.2 CB's impact on the population

Acquisition

- What are the economic and political impacts of the Army's injection of money into the local economy?
- How will the Army's purchase and use of water differentially impact local consumers, positively or negatively?
- How will the Army's purchase and use of water affect the ability of water providers to expand, enhance, or decrease their service?
- Is lack of or differential access to water a source of local conflict?
- Can the Army's purchase and use of water be perceived as fueling local conflict from the point of view of the local population?

Return (sanitation)

- What is the impact of wastewater on the local sanitation system?

4 Conclusions

The assessment framework proposed in this work will enable the U.S. Army to consider the ramifications of siting CBs as part of military operations. While deployed in a foreign nation, U.S. military commanders and planners must be cognizant of how their actions can impact U.S. military operations for good or for ill. This report has specifically highlighted the question of access to potable water. It is no secret that U.S. Forces need potable water; however, providing it should not be detrimental to the local population, whose support the Army needs. Consider a location where the local population has only limited access to potable water and then, compound those concerns with the notion that U.S. military forces will enter these areas and take what its soldiers need to subsist. The result of such concerns can lead to larger problems for military operations. For example, during military operations in Iraq and Afghanistan, the U.S. Army was often criticized for the manner in which day-to-day operations were carried out. These criticisms led to distrust of the U.S. military on the part of the local populations. In turn, the distrust exacerbated difficulties in combating U.S. adversaries. Army actions, such as obtaining access to potable water, must be viewed from a systemic perspective so that their potential impacts can be recognized and assessed for strategic and tactical implications as well.

The proposed framework's impact questions attest to the complexity of the social, cultural, political, economic, and technological relationships between Army and host-nation users of potable water when siting a CB. The questions focus on consideration of the reciprocal impacts between a CB and the local population, given five options for the use of potable water: (1) purchase commercially produced, bottled/packaged water, (2) drill wells, (3) extract water from surface water sources, (4) collect rainwater, or (5) purchase bulk water from a local provider. Depending on the option under consideration, there may be impacts concerning water rights and permits, acquisition and distribution of water, solid waste management, sanitation, or transition of the U.S.-developed system to the host nation.

This report addresses the provision of water at the local level because a local water source is the immediate concern of operational planners. However, it is well recognized that local water provision is embedded in regional, national, and international contexts, and that any basing decisions have impacts across the same range of scales. Ultimately, "a nested,

tiered framework for analysis may help identify the most effective scale for water management; [and] a single scale may not be the most effective in all cases or for all aspects of a single case" (Hering et al. 2015, 480).

The next step leading to the application of the framework will be to address which methods and which data can responsibly be brought to bear in answering the questions contained in the framework. It may prove possible to work with methods, tools, and data that are already available to the Army. Regardless, supporting data would likely be collected both from open sources and from on-site sources. Addressing data sources and analytical methodologies is outside the scope of the present effort, but those topics will be part of research efforts in fiscal year 2017.

References

Alcamo, Joseph, Neville J. Ash, Colin D. Butler, J. Baird Callicott, Doris Capistrano, Stephen R. Carpenter, Juan Carlos Castilla, Robert Chambers, Kanchan Chopra, Angela Cropper, Gretchen C. Daily, Partha Dasgupta, Rudolf de Groot, Thomas Dietz, Anantha Kumar Duraiappah, Madhav Gadgil, Kirk Hamilton et al.[4] 2003. *Ecosystems and Human Well-being: A Framework for Assessment*. A Report of the Conceptual Framework Working Group of the Millennium Ecosystem Assessment. Washington, DC: World Resources Institute and Island Press, 8. Available at http://pdf.wri.org/ecosystems_human_wellbeing.pdf.

Anderson, H. Garth, Stephen W. Maloney, Kurt Kinnevan, Edgar D. Smith, K. James Hay, and Gary L. Gerdes. 2013. *Baseline Water Demand at Forward Operating Bases*. ERDC/CERL TR-13-16. Champaign, IL: ERDC-CERL. Available at http://www.dtic.mil/get-tr-doc/pdf?AD=ADA613424.

ATP 3-37.10. 26 April 2013. *Base Camps*. Washington, DC: U.S. Army Headquarters. NOTE: Distribution limited to agencies of the U.S. Government and their contractors.

ATP 4-44. 2 October 2015. *Water Support Operations*, Glossary, *q.v.,* citing Army Technical Medical Bulletin (TB MED) 577, *Sanitary Control and Surveillance of Field Water Supplies*. Available at http://armypubs.army.mil/doctrine/DR_pubs/dr_a/pdf/atp4_44.pdf.

EP 1105-3-1, *Base Camp Development in the Theater of Operations*, dated 19 January 2009. Available at http://www.publications.usace.army.mil/Portals/76/Publications/EngineerPamphlets/EP_1105-3-1.pdf.

Farmani, Raziyeh, and David Butler. 2014. "Implications of Urban Form on Water Distribution Systems Performance." *Water Resources Management* 28(1): 84. doi: 10.1007/s11269-013-0472-3.

Finewood, Michael H., and Ryan Holifield. 2015. "Critical Approaches to Urban Water Governance: From Critique to Justice, Democracy, and Transdisciplinary Collaboration." *WIREs Water 2* (2015):85–96. doi: 10.1002/wat2.1066.

Harris, Marc (COL), Robert Dixon (LT COL), Nicholas Melin (MAJ), Daniel Hendrex (CSM), Sergeant Major Richard Russo (SGM), and Mr. Michael Bailey. 2014. *Megacities and the United States Army: Preparing for a Complex and Uncertain Future*. Arlington, VA: Office of the Chief of Staff of the Army, Strategic Studies Group, Megacities Concept Team. Available at http://www.army.mil/e2/c/downloads/351235.pdf.

[4] There are 34 additional authors listed on page 6 of the downloadable PDF.

Hart, Steven D., J. Ledlie Klosky, Scott Katalenich, Berndt F. Spittka, and Erik R. Wright. 2014. *Infrastructure and the Operational Art: A Handbook for Understanding, Visualizing, and Describing Infrastructure Systems*. ERDC/CERL TR-14-14. Champaign, IL: ERDC-CERL. Available at http://acwc.sdp.sirsi.net/client/search/asset/1036581.

Hering, J.G., D. L. Sedlak, C. Tortajada, A. K. Biswas, C. Niwagaba, and T. Breu. 2015. "Local Perspectives on Water." *Science* 349(6247): 479–480. Available at http://thirdworldcentre.org/wp-content/uploads/2015/08/Local-perspectives-on-water.pdf.

International Association for Impact Assessment. 2013. "Principles and Guidelines for Social Impact Assessment in the USA." *Impact Assessment and Project Appraisal* 21(3).

Krooks, David A. Lucy A. Whalley, and Harold G. Anderson. 2012. *Contingency Bases and the Problem of Sociocultural Context*. ERDC/CERL TN-12-2. Champaign, IL: ERDC-CERL. Available at http://www.dtic.mil/dtic/tr/fulltext/u2/a568613.pdf.

Kuzdas, Christopher. 2012. "Unpacking water conflict in Guanacaste, Costa Rica." GWF Discussion Paper 1242. Presented at Global Water Forum in Canberra, Australia. Available at http://www.globalwaterforum.org/2012/10/16/unpacking-water-conflict-in-guanacaste-costa-rica/.

Kuzdas, Christopher, Mariel Yglesias, and Benjamin Warner. 2013. "Governing Costa Rica's Water Resources." *Solutions*, 4(4): 31–36. Available at http://thesolutionsjournal.org/node/23918?page=1.

Larson, Kelli L., Arnim Wiek, and Lauren Withycombe Keeler. 2013. "A Comprehensive Sustainability Appraisal of Water Governance in Phoenix, AZ." *Journal of Environmental Management* 116: 58–71. Available at http://www.sciencedirect.com/science/article/pii/S0301479712006019. doi: 10.1016/j.jenvman.2012.11.016.

Rouse, Michael J. 2013a. *Institutional Governance and Regulation of Water Services*. London: IWA Publishing.

_____. 2013b. "Policy Brief: The Urban Water Challenge." *International Journal of Water Resources Development* 29(3): 300–309. doi: 10.1080/07900627.2013.791568.

Sairinen, Rauno. 2009. "Social Impact Assessment for Environmental Disaster Management." In *Building Safer Communities: Risk Governance, Spatial Planning, and Responses to Natural Hazards*, ed. U. Fra Paleo, Volume 58 in NATO Science for Peace and Security Series - E: Human and Societal Dynamics, 137–147. Amsterdam: IOS Press.

Swyngedouw, Erik. 2004. *Social Power and the Urbanization of Water: Flows of Power*, New York: Oxford University Press.

TB MED 577. 1 May 2010. *Sanitary Control and Surveillance of Field Water Supplies*. Available at http://armypubs.army.mil/med/DR_pubs/dr_a/pdf/tbmed577.pdf.

Turnley, Jessica G. 2002. "Social, Cultural, Economic Impact Assessments: A Literature Review." Prepared for The Office of Emergency and Remedial Response, U.S. Environmental Protection Agency. Albuquerque, NM: Galisteo Consulting Group, Inc.

Vanclay, Frank. 2003. "International Principles for Social Impact Assessment." *Impact Assessment and Project Appraisal* 21(1): 5–12.

Wiek, Arnim, and Kelli L. Larson. 2012. "Water, People, and Sustainability – A Systems Framework for Analyzing and Assessing Water Governance Regimes." *Water Resources Management* 26:3153-3171. doi: 10.1007/s11269-012-0065-6.

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14. ABSTRACT

If strategically sited, a contingency base (CB) can serve as a force multi-plier in relations between governments and civilians. Although both of the U.S. Army's key doctrinal sources for CB planning and design clearly recognize that CBs are affected by host-nation populations and also affect those populations directly, neither source provides much concrete help to the planners who are expected to analyze those reciprocal impacts. Yet, while deployed in a foreign nation, U.S. military commanders and planners must be cognizant of how their actions can impact U.S. military operations for good or for ill. This work supports military planners tasked with selecting CB locations by presenting an assessment framework to conduct a scientifically supportable socioecological systems analysis of a CB's use of a resource—in this case, potable water. The proposed assessment framework will enable the U.S. Army to consider the ramifications of siting CBs as part of military operations. Addressing data sources and analytical methodologies will be part of follow-on research efforts.

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